



# New record of the snake *Geophis turbidus* (Squamata: Dipsadidae) from Hidalgo, Mexico, with annotations of a juvenile specimen

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**Abstract:** We record for the first time the recently described snake *Geophis turbidus* from the state of Hidalgo, Mexico. The species was recorded in cloud and pine forests, and this report extends the distribution of this species approximately 25 km from its previously known occurrence. In this paper, we also report the first description of a juvenile specimen, along with data on the natural history, morphology, and conservation of this species.

**Key words:** *Geophis turbidus*, cloud forest, new record, juvenile, Hidalgo

Mexico is notably rich in species of amphibians and reptiles, and the number of species (ca. 1,227) has increased in the last decade with description of new species and new records (Campbell and Flores-Villela 2008; Wilson et al. 2010, 2013a, 2013b). Of this diversity, a high percentage of amphibians (66.8%) and reptiles (57.2%) are endemic to Mexico (Wilson et al. 2013a, 2013b). Also studied is species richness by vegetation type, such as cloud forest (Ramírez-Bautista and Cruz-Elizalde 2013), tropical forest (Johnson et al. 2010), and arid and semi-arid environments (Lavín-Murcio and Lazcano 2010). A remarkable number of new records of species have been found from many states of Mexico (e.g., Roth-Monzón et al. 2011; Mejenes-López and Hernández-Bautista 2013; Van der Heiden and Flores-Villela 2013; Badillo-Saldaña et al. 2014; Bello-Sánchez et al. 2014; Lara-Tufiño et al. 2014), and some Mexican species have been rediscovered (Delia et al. 2013; Ramírez-Bautista et al. 2013).

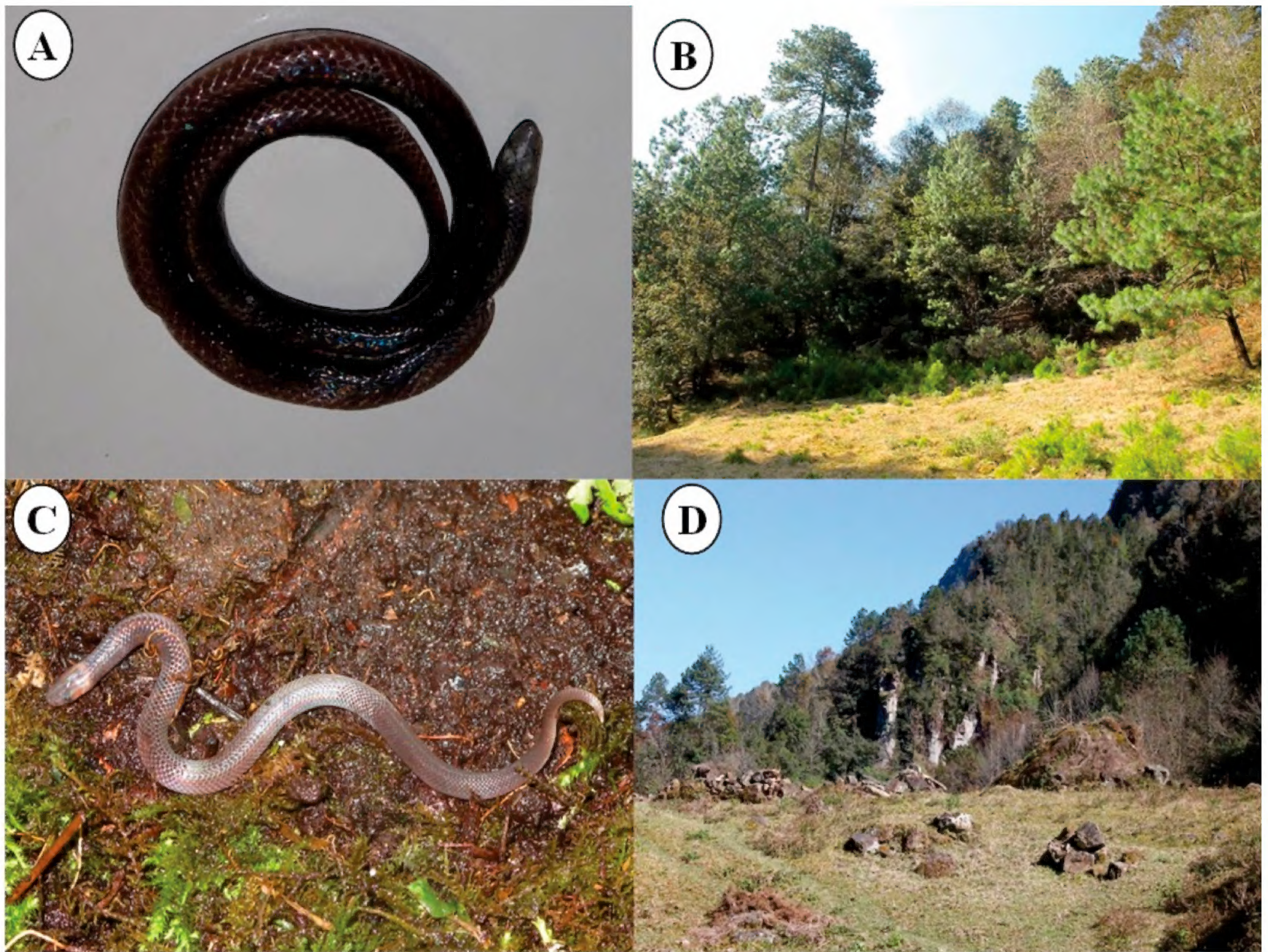
*Geophis* Wagler, 1830 is one of the most diverse genus of snakes in the American continent, with 49 recognized species (Pavón-Vázquez et al. 2013). This genus has a wide distribution range, from northern Mexico, through Central America to northern and western Colombia (Wilson and Townsend 2007). The genus is composed of seven species groups: *Geophis chalybeus* Wagler, 1830,

*G. championi* Boulenger, 1894, *G. dubius* (Peters, 1861), *G. latifrontalis* Garman, 1884, *G. omiltemanus* (Günther, 1893), *G. semidoliatus* (Duméril, Bibron and Duméril, 1854), and *G. sieboldi* (Jan, 1862) (*sensu* Downs 1967), which is supported on phenetic analysis (Nieto-Montes de Oca 2003; Townsend and Wilson 2006; Wilson and Townsend 2007). Taxonomic studies of the genus have generated descriptions of new species (Pérez-Higareda et al. 2001; Myers, 2003; Nieto-Montes de Oca 2003; Townsend and Wilson 2006; Pavón-Vázquez et al. 2011, 2013).

The description of *Geophis turbidus* Pavón-Vázquez, Canseco-Márquez & Nieto-Montes de Oca, 2013, contains information on morphological variation, distribution, natural history, and conservation (Pavón-Vázquez et al. 2013). In this study, we report the occurrence of *G. turbidus* in Hidalgo state, Mexico, for the first time, and we also include information on the species' natural history, as well as the morphological description of a juvenile (scutellation and color pattern), which is not available in the original description (Pavón-Vázquez et al. 2013). Based on the little information that exists on the species, our new data adds to the knowledge on morphological variation, potential distribution in different environments, and how best to conserve this recently described species.

From June 2009 to February 2010 field surveys were conducted to determine species richness and diversity of reptiles in the Municipality of Tenango de Doria, Hidalgo, Mexico. Vegetation types present in Tenango de Doria include cloud forest, pine forest, oak-pine forest, and tropical rain forest to a lesser extent (Luna-Vega et al. 2000). On 19 June 2009, we located an adult male of *G. turbidus* (CIB-4450; Figure 1A) at Agua Zarca, Tenango de Doria (20°18'38.08" N, 098°16'02.78" W; datum WGS84), at an elevation of 2,255 m above sea level (a.s.l.), under a rock in pine forest (Figure 1B). This specimen has a snout-vent length (SVL) 255.6 mm and a body length (BL) of 298.8 mm. A second individual, a juvenile male (CIB-4451; Figure 1C) was collected on 17 November 2009





**Figure 1.** Adult male (**A**; CIB-4450) and pine forest (**B**) of *Geophis turbidus* from Agua Zarca, and juvenile (**C**; CIB-4451) and cloud forest (**D**) of the locality La Viejita, from Tenango de Doria, Hidalgo, Mexico.

at La Viejita (20°19'42.34" N, 098°14'47.65" W; datum WGS84) under a rock on the edge of a grazing area in a patch of cloud forest (Figure 1D) at 1,711 m a.s.l. This second specimen has a SVL of 99.7 mm and a BL of 114.1 mm. The environmental temperature was 10°C and the microenvironmental temperature was 12°C. Specimens of *G. turbidus* were collected and transported to the Laboratorio de Ecología de Poblaciones of Centro de Investigaciones Biológicas (CIB) from the Universidad Autónoma del Estado de Hidalgo (UAEH) under an approved scientific permit from SEMARNAT (#SGPA/DGVS/02726/10). Photographs of the specimens were taken in life and after they were fixed in formalin (10%) and preserved in ethanol (70%; Casas-Andreu et al. 1991). Morphological measurements were made by using an electronic calliper (0.01 mm).

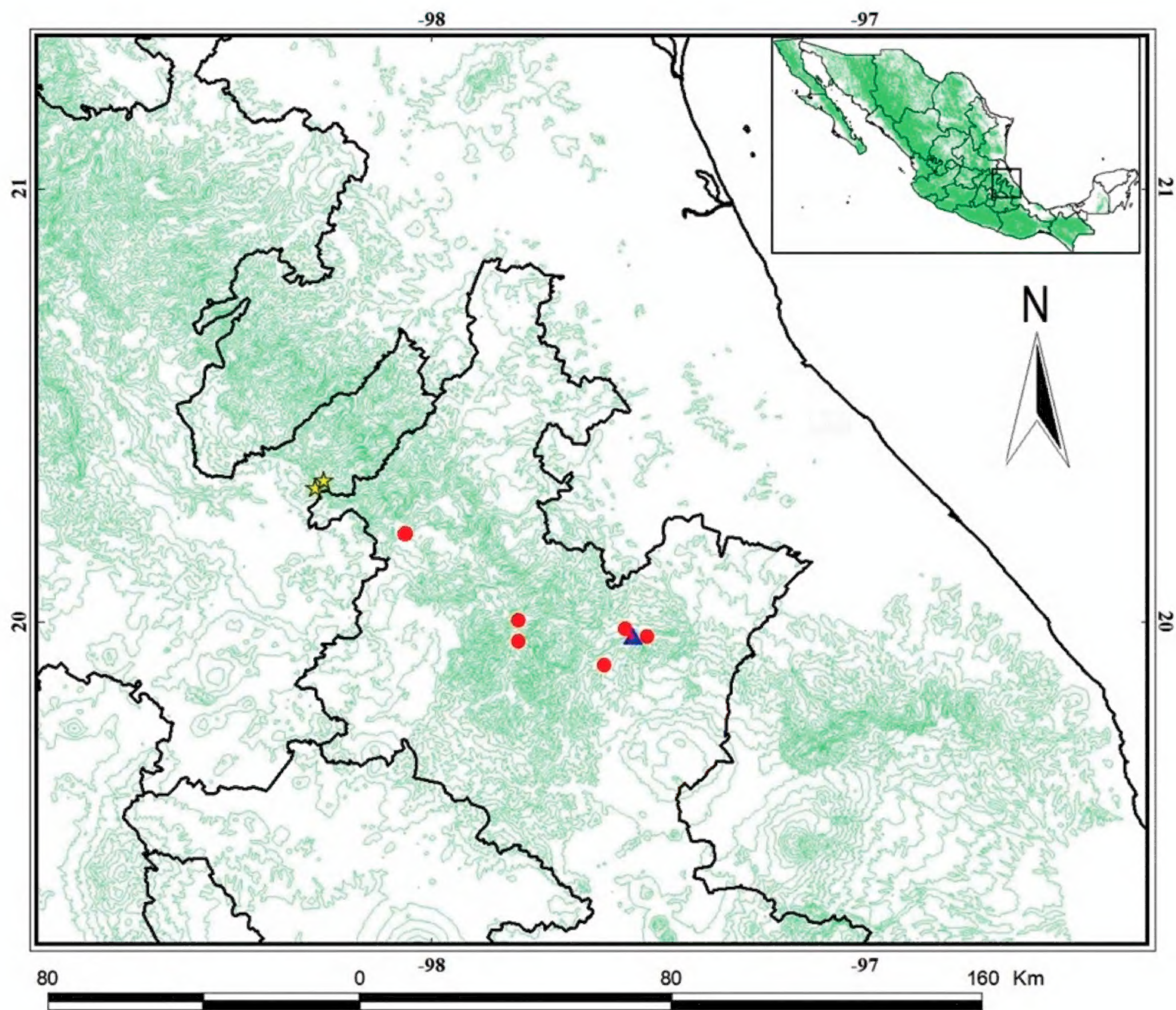
The nomenclature and analysis of scutellation were based on the methods by Downs (1967), Savage and Watling (2008), and Pavón-Vázquez et al. (2013). The specimens were identified according to the keys to the genus *Geophis* (Wilson and Townsend 2007) and from description of the species (Pavón-Vázquez et al. 2013).

We also compared the morphological characteristics of color and scutellation of the specimens collected with other representatives of the genus *Geophis* from Hidalgo (i.e., *Geophis latifrontalis* [species group: *latifrontalis*], *G. mutitorques* [species group: *latifrontalis*] and *G. semidoliatus* [species group: *semidoliatus*; Downs 1967]; Ramírez-Bautista et al. 2010). Identification of species was confirmed by Uriel Hernández Salinas, and corroborated by Luis Canseco Márquez.

These new records of the adult male and juvenile male from Hidalgo, represent a straight-line range extension of 24 km and 25 km, respectively, from the nearest locations, 16.09 km southwest of Villa Juárez, Xicotepec de Juárez, Puebla, and 83.6 km and 82.5 km, respectively, from the type locality, 3.5 km west of Xocoyolo, Municipality of Cuetzalan, Puebla, Mexico (Pavón-Vázquez et al. 2013; Figure 2).

The adult male (CIB-4450) resembles the holotype and the paratypes in scutellational features (Table 1; Pavón-Vázquez et al. 2013); however, it has a larger SVL, TL and body length (BL; Table 1). The juvenile specimen (CIB-4451) differs from the adult male in characteristics



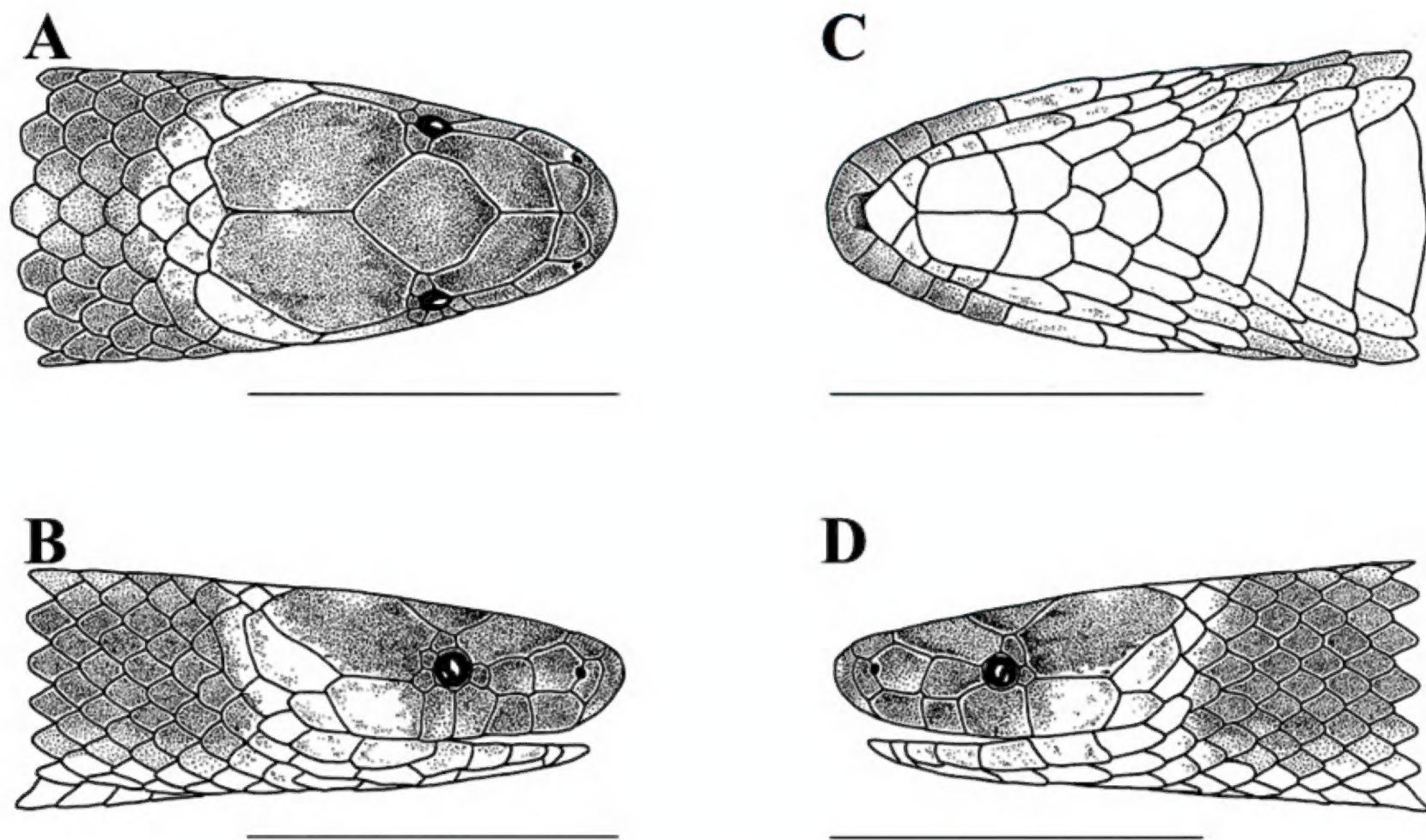


**Figure 2.** Map of the distribution of *Geophis turbidus* in Hidalgo and Puebla states, Mexico (yellow stars, Hidalgo specimens; blue triangle, type locality in Puebla; red circles, localities of paratypes in Puebla). The green lines represent the lift curves each 250 m a.s.l.

**Table 1.** Scutellation and morphometrics of holotype of *Geophis turbidus* (MZFC 27254; Pavón-Vázquez et al. 2013), and specimens reported (CIB 4450-4451) from Tenango de Doria, Hidalgo, Mexico. The count of scales is represent how left/right, and maxillary teeth (right side) was obtained from Pavón-Vázquez et al. (2013; \*EBUAP 1021).

Characteristics	MZFC 27254	CIB-4450	CIB-4451
Sex/age class	Adult female	Adult male	Juvenile male
Prefrontal scale	1/1	1/1	1/1
Postocular scale	1/1	1/1	1/2
Preocular scale	0/0	0/0	0/1
Supraocular	Present	Present	Present
Supralabials scales	6/6	6/6	5/6
Infralabials scales	6/6	6/6	6/6
Dorsal body scales	17-17-17	17-17-17	16-17-17
Ventrals scales	136	135	137
Cloacal scute	Single	Single	Single
Subcaudal scales	26	33	34
Types of dorsal scales	Smooth except for weak keels and apical pits on those above vent region	Smooth except for weak keels above vent	Smooth but with weak keels on the posterior region of body and tail
Maxillary teeth	9*	9	9
BL (mm)	285	298.8	114.1
SVL (mm)	249	255.6	99.7
TL (mm)	36	43.2	14.4





**Figure 3.** Head of juvenile of *Geophis turbidus* (CIB-4451): (A) dorsum; (B) right side; (C) venter; (D) left side. Horizontal bars equal 5 mm.

of scutellation and color pattern (CIB-4450; Figure 3A-D). The dorsal scales are in 16-17-17 rows (17-17-17 in MZFC 27254 and CIB-4450; Table 1; Pavón-Vázquez et al. 2013). The juvenile has two postoculars on the right side (Figure 3B, Table 1) compared with the adult holotype (MZFC 27254) and adult male of Hidalgo (CIB-4450), which have one postocular (Table 1). On the right and left side, there are six and five supralabials, respectively (6/6 in MZFC 27254 and CIB-4450; Table 1), third and fourth supralabials in contact with the orbit on the right side (Figure 3B); on the left side, the third labial enters the orbit (Figure 3D). The mental scale scarcely is in contact with the first pair of chin shields. The second pair of chin shields is in medial contact, not separated by a first gular scale as occurs in the adult specimens (MZFC 27254, CIB-4450; Figure 3C).

The color pattern in preserved specimen (CIB-4450) is similar to holotype (MZFC 27254). The background color of the dorsal and lateral portions of the head is olive gray with indistinct dark gray spots on the parietal and frontal scales; the mental region and chin shields are cream colored. The dorsal surface of the body and tail are predominantly dark gray (Figure 1A), which becomes pale gray toward the ventral region of the body. The ventral scales are cream colored, with pale brown spots on their anterior portion, and the ventral region of the tail is uniformly dark brown.

In life, the juvenile specimen (CIB-4451) color pattern is: dorsal region of head pale gray (Figure 1C); dorsal region of body and tail dark gray, with a vertebral line cream; lateral region of body pale pink to edge of ventrals, which are cream colored, as are subcaudals. Pale pink collar on posterior region of head, beginning

on posterior edge of parietal scales and extending posteriorly to posterior end of second mid dorsal scale; laterally across temporal scales to reach supralabials posterior to eye and sublabials; collar reaches the fifth and sixth supralabials on right side (Figure 1C), and third and fourth supralabials on left side.

The two specimens from the Municipality of Tenango de Doria inhabit cloud forest (CIB-4451) at an elevation of 1,711 m a.s.l. and also pine forest (CIB-4450) at an elevation of 2,255 m a.s.l. These environmental features (vegetation type of pine forest and altitude) had not been previously reported for the species (Pavón-Vázquez et al. 2013). Specimens were found under rocks, which is a common microhabitat of species of the genus *Geophis* (Downs 1967). The stomach contents of the adult male contained ants (Hymenoptera: Formicidae), and vegetable and mineral matter, which suggests an insectivorous diet. The stomach of the juvenile specimen was empty. The adult male and juvenile had large fat bodies, with a mass of 0.1970 g and 0.0320 g, respectively.

The discovery of this snake species in pine forest and cloud forest vegetation (as already known at the type locality in Puebla) in Hidalgo points the importance of the conservation of these forest types as repositories of a considerable number of endemic Mexican amphibians and reptiles (Flores-Villela et al. 2010). In addition, the records reported here extend its distribution to the northwest of the previously-reported records from the Sierra Madre Oriental (Pavón-Vázquez et al. 2013).

Given the importance of the mountains of central Mexico for endemic reptile (Flores-Villela et al. 2010), it is critical to note that these are areas subject to



significant anthropogenic damage in pine, oak, pine-oak, or cloud forests (Ponce-Reyes et al. 2012). It is in cloud forests where most specimens of *G. turbidus* have been found, and given the restricted distribution of this snake, we have used the Environmental Vulnerability Score (EVS) proposed by Wilson et al. (2013a) to assess its conservation status. We determined the EVS as 14, which places this species in the category of high vulnerability, based on the following calculations: (i) geographic distribution (5: occurrence only in Mexico, but not restricted to the type locality); (ii) ecological distribution (7: occurrence in two vegetation types, cloud forest and pine forest), and (iii) degree of human persecution (2: semifossorial habits, not venomous, sometimes escapes the attention of humans). Because of its recent description, its conservation status has not been assessed yet by the Mexican government (NOM-059-SEMARNAT; SEMARNAT 2010) or by the International Union for Conservation of Nature and Natural Resources (IUCN). Accordingly, there is a need for an assessment of the level of degradation of its habitat, its population status, and aspects of its natural history.

This new record of *G. turbidus* increases the number of snake species in Hidalgo state to 84 (Ramírez-Bautista et al. 2010; Badillo-Saldaña et al. 2014). With the new record of this species from Hidalgo, the importance and necessity for conservation of the pine and cloud forests where *G. turbidus* and other species of amphibians and reptiles live is highlighted.

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## LITERATURE CITED

- Badillo-Saldaña, L.M., C. Berriozabal-Islas and A. Ramírez-Bautista. 2014. New record of the snake *Drymobius chloroticus* (Cope, 1886) (Squamata: Colubridae) from Hidalgo, Mexico. Check List 10(1): 199–201. doi: [10.15560/10.1.199](https://doi.org/10.15560/10.1.199)
- Bello-Sánchez, E.A., J.E. Morales-Mávil, E.A. Suárez-Domínguez, C.R. Corona-López and O.I. Martínez-Vaca León. 2014. Ampliación de la distribución altitudinal y geográfica de *Lithobates johni* y nuevo registro para Veracruz, México. Revista Mexicana de Biodiversidad 85(3): 979–981. doi: [10.7550/rmb.43434](https://doi.org/10.7550/rmb.43434)
- Campbell, J.A. and O. Flores-Villela. 2008. A new long-tailed rattlesnake (Viperidae) from Guerrero, México. Herpetologica 64(2): 246–257. doi: [10.1655/07-054.1](https://doi.org/10.1655/07-054.1)
- Casas-Andreu, G., G. Valenzuela-López and A. Ramírez-Bautista. 1991. Cómo hacer una colección de anfibios y reptiles. Cuadernos del Instituto de Biología 10, Universidad Nacional Autónoma de México. D. F. 68 pp.
- Delia, J.R.J., J.L. Whitney and T. Burkhardt. 2013. Rediscovery of “lost” treefrogs from the Oaxacan highlands of Mexico. Biodiversity and Conservation 22(6–7): 1405–1414. doi: [10.1007/s10531-013-0481-9](https://doi.org/10.1007/s10531-013-0481-9)
- Downs, F.L. 1967. Intrageneric relationships among colubrid snakes of the genus *Geophis* Wagler. Miscellaneous Publications Museum of Zoology, University of Michigan 131: 1–193. <http://deepblue.lib.umich.edu/bitstream/handle/2027.42/56375/MP131.pdf?sequence=1>
- Flores-Villela, O., L. Canseco-Márquez and L.M. Ochoa-Ochoa. 2010. Geographic distribution and conservation of the Mexican central highlands herpetofauna; pp. 303–321, in: L.D. Wilson, J.H. Townsend and J.D. Johnson (eds.). Conservation of the Mesoamerican Amphibians and Reptiles. Eagle Mountain, Utah; Eagle Mountain Publisher, L. C.
- Johnson, J.D., V. Mata-Silva and A. Ramírez-Bautista. 2010. Geographic distribution and conservation of the herpetofauna of southeastern Mexico; pp. 322–369, in: L.D. Wilson, J.H. Townsend and J.D. Johnson (eds.). Conservation of the Mesoamerican Amphibians and Reptiles. Eagle Mountain, Utah; Eagle Mountain Publisher, L. C.
- Lara-Tufiño, D., R. Hernández-Austria, L.D. Wilson, C. Berriozabal-Islas and A. Ramírez-Bautista. 2014. New state record for the snake *Amastridium sapperi* (Squamata: Dipsadidae) from Hidalgo, México. Revista Mexicana de Biodiversidad 85(2): 654–657. doi: [10.7550/rmb.40543](https://doi.org/10.7550/rmb.40543)
- Lavín-Murcio, P.A. and D. Lazcano. 2010. Geographic distribution and conservation of the herpetofauna of northern Mexico; pp. 275–300, in: L.D. Wilson, J.H. Townsend and J.D. Johnson (eds.). Conservation of the Mesoamerican Amphibians and Reptiles. Eagle Mountain, Utah; Eagle Mountain Publisher, L. C.
- Luna-Vega, I., O. Alcántara-Ayala, J.J. Morrone and D. Espinosa-Organista. 2000. Track analysis and conservation priorities in the cloud forest of Hidalgo, México. Diversity and Distribution 6(3): 137–143. doi: [10.1046/j.1472-4642.2000.00079.x](https://doi.org/10.1046/j.1472-4642.2000.00079.x)
- Mejenes-López, S. de M.A. and M. Hernández-Bautista. 2013. Primer registro de *Crocodylus moreletii* (Reptilia: Crocodylia) para Hidalgo, México. Revista Mexicana de Biodiversidad 84(3): 999–1001. doi: [10.7550/rmb.32508](https://doi.org/10.7550/rmb.32508)
- Myers, C.W. 2003. Rare snakes—Five new species from eastern Panama: Reviews of northern *Atractus* and southern *Geophis* (Colubridae: Dipsadinae). American Museum Novitates 3391: 1–47. doi: [10.1206/0003-0082\(2003\)391<0001:RSFNSF>2.0.CO;2](https://doi.org/10.1206/0003-0082(2003)391<0001:RSFNSF>2.0.CO;2)
- Nieto-Montes de Oca, A. 2003. A new species of the *Geophis dubius* group (Squamata: Colubridae) from the Sierra de Juárez of Oaxaca, Mexico. Herpetologica 59(4): 572–585. doi: [10.1655/02-05](https://doi.org/10.1655/02-05)
- Pavón-Vázquez, C.J., U.O. García-Vázquez, J.C. Blancas-Hernández and A. Nieto-Montes de Oca. 2011. A new species of the *Geophis sieboldi* group (Squamata: Colubridae) exhibiting color pattern polymorphism from Guerrero, Mexico. Herpetologica 67(3): 332–343. doi: [10.1655/HERPETOLOGICA-D-11-00003.1](https://doi.org/10.1655/HERPETOLOGICA-D-11-00003.1)
- Pavón-Vázquez, C.J., L. Canseco-Márquez and A. Nieto-Montes de Oca. 2013. A new species in the *Geophis dubius* group (Squamata: Colubridae) from Northern Puebla, México. Herpetologica 69(3): 358–370. doi: [10.1655/HERPETOLOGICA-D-12-00095](https://doi.org/10.1655/HERPETOLOGICA-D-12-00095)
- Pérez-Higareda, G., H.M. Smith and M.A. López-Luna. 2001. A new *Geophis* (Reptilia: Serpentes) from southern Veracruz, Mexico. Bulletin of the Maryland Herpetological Society 37: 42–48.
- Ponce-Reyes, R., V.H. Reynoso-Rosales, J.E.M. Watson, J. Van Der Wal, R.A. Fuller, R.L. Pressey and H.P. Possingham. 2012. Vulnerability of cloud forest reserves in México to climate change. Nature Climate Change 2(6): 448–452. doi: [10.1038/nclimate1453](https://doi.org/10.1038/nclimate1453)
- Ramírez-Bautista, A. and R. Cruz-Elizalde. 2013. Reptile community



- structure in two fragments of cloud forest of the Sierra Madre Oriental, Mexico. North-Western Journal of Zoology 9(2): 410–417. <http://biozoojournals.3x.ro/nwjz/index.html>
- Ramírez-Bautista, A., C. Berriozabal-Islas, R. Cruz-Elizalde, U. Hernández-Salinas and L.M. Badillo-Saldaña. 2013. Rediscovery of the snake *Chersodromus rubriventris* (Squamata: Colubridae) in cloud forest from Sierra Madre Oriental, México. Western North American Naturalist 73(3): 392–398. doi: [10.3398/064.073.0303](https://doi.org/10.3398/064.073.0303)
- Ramírez-Bautista, A., U. Hernández-Salinas, F. Mendoza-Quijano, R. Cruz-Elizalde, V.D. Vite-Silva, B.P. Stephenson and A. Leyte-Manrique. 2010. Lista anotada de los anfibios y reptiles del estado de Hidalgo, México. Universidad Autónoma del Estado de Hidalgo, Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, México. 104 pp.
- Roth-Monzón, A.J., A.A. Mendoza-Hernández and O. Flores-Villela. 2011. *Lampropeltis ruthveni* (Serpentes: Colubridae) from the state of Hidalgo, México. Southwestern Naturalist 56(3): 430–431. doi: [10.1894/No8-FRMC-02.1](https://doi.org/10.1894/No8-FRMC-02.1)
- Savage, J.M. and J.I. Watling. 2008. Not so rare snakes: a revision of the *Geophis sieboldi* group (Colubridae: Dipsadinae) in lower Central America and Colombia. Zoological Journal of the Linnean Society 153(3): 561–599. doi: [10.1111/j.1096-3642.2008.00400.x](https://doi.org/10.1111/j.1096-3642.2008.00400.x)
- SEMARNAT (Secretaría de Medio Ambiente y Recursos Naturales). 2010. Norma Oficial Mexicana NOM-059-SEMARNAT-2010, Protección ambiental, especies nativas de México de flora y fauna silvestres, categorías de riesgo y especificaciones para su inclusión, exclusión o cambio – Lista de especies en riesgo. Diario Oficial de la Federación, segunda sección; 30 december: 1–78.
- Townsend, J.H. and L.D. Wilson. 2006. A new species of snake of the *Geophis dubius* group (Reptilia: Squamata: Colubridae) from the Sierra de Omoa of northwestern Honduras. Proceedings of the Biological Society of Washington 119(1): 150–159. doi: [10.2988/0006-324X\(2006\)119\[150:ANSOSO\]2.0.CO;2](https://doi.org/10.2988/0006-324X(2006)119[150:ANSOSO]2.0.CO;2)
- Van der Heiden, A.M. and O. Flores-Villela. 2013. New records of the rare Sinaloan Long-tailed Rattlesnake, *Crotalus stejnegeri*, from southern Sinaloa, Mexico. Revista Mexicana de Biodiversidad 84(4): 1343–1348. doi: [10.7550/rmb.35729](https://doi.org/10.7550/rmb.35729)
- Wilson, L.D. and J.H. Townsend. 2007. A checklist and key to the snakes of the genus *Geophis* (Squamata: Colubridae: Dipsadinae), with commentary on distribution and conservation. Zootaxa 1395: 1–31. <http://www.mapress.com/zootaxa/2007f/zo1395p031f.pdf>
- Wilson, L.D., V. Mata-Silva and J.D. Johnson. 2013a. A conservation reassessment of the reptiles of Mexico based on the EVS measure. Amphibian & Reptile Conservation 7(1): 1–47. <http://amphibian-reptile-conservation.org/archive.html>
- Wilson, L.D., J.D. Johnson and V. Mata-Silva. 2013b. A conservation reassessment of the amphibians of Mexico based on the EVS measure. Amphibian & Reptile Conservation 7(1): 97–127. <http://amphibian-reptile-conservation.org/archive.html>
- Wilson, L.D., J.H. Townsend and J.D. Johnson. 2010. Conservation of the Mesoamerican Amphibians and Reptiles. Eagle Mountain Publisher, L. C.: Eagle Mountain, Utah, U.S.A. 812 pp.

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